A Network Visualization Approach and Global Stock Market Integration

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Abstract

This paper applies a visualized network approach to explain the tendency of integration or co-movement among global equity markets. We utilize daily prices of stock market indices of 57 countries from January 1997 to August 2012 to establish both the Minimum Spanning Tree Network (MSTN) and Graphic Network (GN). We study network features including connectivity and centrality through robust indicators. Our results clearly show that there has been a tendency over time for markets to become more integrated globally even during periods of market stress. The centrality results suggest the US and Hong Kong markets have been the most dominant markets in their geographic region. For Europe, we find three dominant centres, the UK, France and Germany in contrast to previous literature suggesting that the UK was the dominant country. We further identify that Japan and Australia, instead of acting as dominant countries in their region, serve as bridging countries between the region and the rest of the world. Finally, we find that Africa does not form a cluster and individual African countries tend to connect to other developed markets in a scattered manner.

Key words: Network, Stock Market, Integration

JEL classification: G12, G15, G18, C32, F02, C45

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1. Introduction

Financial market integration is an important topic in finance (Madhavan, 2000). It underpins a number of important issues such as price discovery, equity dynamics and information shock transmission. Since the 2008 financial crisis, these phenomena have been re-examined. For example, Lane and Milesi-Ferretti (2010), Crotty (2009), Huyghebaert and Wang (2010) and Dabrowski (2010) have examined the integration relationship among markets in the world financial system and contagion. The general finding is that impacts from a crisis spread more quickly in a highly integrated financial system than a less connected system. In contrast, an individual financial market or segment inside a highly integrated system would benefit from the high level of integration when the financial system was recovering from the turbulence.

Previous studies of financial market integration normally utilize econometric techniques such as cointegration (see Campbell and Hamao, 1992; Forbesand Rigobon, 2002; Voronkova, 2004 etc.). Such approaches are restricted to examining the dynamics of a system and the modelling techniques are commonly correlation-based methods. One prominent issue with such methods is that even perfectly co-integrated variables do not necessarily guarantee high correlations. Additionally, in multi-factor modelling, there is the problem of choosing relevant factors. Moreover, when a few countries are significantly driven by the same economic factor, the R-squares given by these models are usually large, which leads to inflated cointegration results (Pukthuanthong and Roll, 2009). Even where a positive relationship between correlation and integration is found (see Edison, Levine, Ricci, and Sløk, 2002; Forbes and Rigobon, 2002; Bekaert, Harvey and Ng, 2005; Bekaert, Hodrick and Zhang, 2008), we still cannot conclude whether such results are unbiased.

In this paper, we propose to use a network visualization approach to examine global stock market integration. According to Allen and Babus (2008), mapping a financial network is “the first and crucial step in understanding a modern financial system”. In general, a social network consists of a large group of ‘individuals’ including both core and non-core groups that are distinguished by the level of connectivity of the individual to others. The connection between ‘individuals’ can be direct or indirect through paths.

Our study is based on the rationale that a social type network can capture connections within the global financial system. We construct correlation-based distance measures of57 stock market indices over a 21-year period and identify the connections between them. With this approach we are able to study the relationship between the dynamics of the network structure and significant market events as well as capturing important market phenomena such as markets’ connectivity, clustering and dominant markets’ centrality[1]. We also examine the effect of various financial crises including the latest 2008 market meltdown on the network relations; for instance, the level of integration locally and globally pre and post the crises.

In this study, we utilize two approaches from the network literature: minimum spanning tree networks (MSTN) and graph networks (GN) (see Onnela, Kaski and Kertész, 2004). Each approach has its own distinct advantages but they also complement each other. Both MSTNs and GNs separate the core from the non-core countries in the network. The GN’s most prominent advantage is to visually reveal financial clusters, while the MSTN is good at revealing the connectivity and betweeness of markets.

[1] Another important feature of a network is betweeness, which refers to the number of times a node is passed when other nodes need to establish links with it and other nodes in the network. In our study, we use the minimum spanning tree method to filter links and therefore, betweeness is not applicable in this setting.

The first main finding of our study is that there is increasing integration of stock markets throughout the sample period occurring at the regional level. Since the 2007/8 crisis, the level of integration in the global market has greatly increased. We also note that, post the 2008 crisis, the European region/cluster first moved away from the US before moving back closer. Another key finding is that the regional financial centres appearing in the GN network provide evidence supporting emerging market economy theory, which anticipates the new economic geography with a shift away the US and West-Europe towards Asia and some other fast developing countries and regions. Finally, at the individual country level, we find interesting evidence that while countries like Japan and Australia are important in their region in terms of its size, connectivity and importance coefficient they do not show centrality in the Asia-Pacific cluster. Instead they appear to act as bridging countries between the region and the rest of the world. For Africa, although many countries such as South Africa emerge fast, we do not find them highly significant in the global financial market or form a regional cluster. Instead, African countries seem to connect to developed markets in other continents individually.

This paper contributes to the existing literature on financial market integration in four ways. First, we establish a financial network without relying on the assistance of a real goods trading network for providing a distance measure. The typical distance measure suggested by the literature could be the Gower distance measure, which helps to select the unique linkage of a country in the minimum spanning tree avoiding zero or negative values. But in this paper, we improve the method by proposing a simpler measure that still keeps the advantages and features of the Gower distance (see Equation 4). In this new measure, the highly connected countries that carry large correlations will have shorter distance and this will provide better clarity in showing the closeness between such markets. Second, we develop two different types of financial networks with separate indicators of connectivity and centrality - the importance coefficient (IC) and clustering coefficient (CC). These different measures provide robust and complementary results to explain the degree of centrality and structure of financial clusters. Through comparing the IC and CC, we are able to obtain new results that the past literature on integration has not identified. For example, Europe has appeared joint-power in driving regional economy rather than the UK has been historically the sole leading country. Third, we use the constructed networks to examine the impact of various financial crises on countries both globally and regionally. For example, we identify that countries tend to move away from the original trouble countries/regions during crises but move back during the recovery. Such pattern holds not only for the recent liquidity crisis but also the previous Asian finance crisis and dot com bubble. Fourth, to our knowledge, this is the first paper in the literature using a network approach to identify new financial centres in regional and global clusters. We also find evidence that countries such as Japan and Australia surprisingly do not appear to be regional centres. Instead, they serve more as bridging countries to connect the Asia-Pacific cluster to other clusters.

The remainder of the paper is as follows. Section 2 examines the literature on network applications in finance and financial market integration. Section 3outlines the methodologies used in the construction of the financial networks and the calculations of relevant measurement coefficients. Section 4 presents the main findings of this network study and Section 5 concludes.

2. Literature

The literature on market linkages, integration and contagion is extensive. It has been seen that the global market integration implies impacts on diversification strategies, market growth and risk sharing etc. Campbell and Hamao (1992), Campbell and Ammer (1993) and Ammer and Mei (1996) are typical examples. They use the Campbell and Shiller (1988) approximate present value model for different countries. They first decompose excess stock return innovations into news of future excess returns, dividend growth rates, interest rates, and exchange rates; and then, use a vector autoregression (VAR) model to look at the co-movements of these components.

The relative importance of different types of international linkages among the selected economies can be assessed. Usually, the US and UK are found to have a high level of financial correlation linkage for each pair of the four components and continue to increase after the abandonment of the Bretton Woods arrangement in the 1970s.[2] Further, they argue, the upward trend has often been underestimated. Similarly, Chen, Firth and Rui (2000) utilize a Johansen multivariate cointegration analysis of the stock indices of six Latin American countries from 1995 to 2000. They find a high level of stock market integration post the Asian and Russian crises, which suggest that the potential for diversifying risk by investing in different Latin American markets is limited.

Forbes and Rigobon (2002) examine stock market interdependence and contagion effects following shocks from the 1987 US market crash, the 1994 Mexican devaluation and the 1997 Asian crisis. Contagion is defined as a significant increase in market co-movement after a shock to one country. They find that heteroscedasticity causes bias in cross-market correlation coefficients for 29 countries and hence, lead to evidence of increasing conditional correlations among markets after experiencing a shock from financial crises. However, after adjusting for the bias of correlations induced by heteroscedasticity, they find that unconditional correlation coefficients show no evidence of contagion. Campbell, Koedijk and Kofman (2002) apply Value at Risk quantile estimation to investigate correlation structure between some stock markets and the US government bond from May 1990 to December 1999[3]. The conditional correlations between international equities significantly increased during periods of extreme downside risk, which indicates markets are more integrated,

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[2]The Bretton Woods arrangement is a system of monetary management, which established the rules for commercial and financial relations among the world's major industrial states in the middle of 20th century. In 1971, US dollar suspended the convertibility into gold due to the currency had been struggled through most of the period of the arrangement, and begin the breakdown of the Bretton Woods system, afterwards the arrangement was abandoned.

[3]VaR quantile estimation is summarised as return estimate from standard deviation with percentage of confidence level of the VaR normal distribution. The "quantile correlation measure" is correlation calculated from returns under VaR quantile estimation.

contagious but less diversifiable during ‘bear’ market periods.

Voronkova (2004) examine the cointegration structure[4] between European emerging and mature markets together with the US market. There is strong evidence of six cointegrating vectors, showing that emerging markets have become increasingly integrated with the global market despite instability and structural changes intrigued by market shocks (also see Granger and Terasvirta, 1993 and Chelley-Steeley, 2005). However, Gilmore, Lucey and McMaus (2008) find no evidence of cointegration when they repeat the same experiment using the Johansen cointegration analysis from the period from July 1994 to February 2004. The co-movement structure between the emerging and mature markets was disrupted by short-term domestic factors, such as falling economic growth rates or periods of instability[5].

Pukthuanthong& Roll (2009) study the global co-integrating relationship among 82 indices over a long time period[6]. Their multi-factor modelling suggests that a significant increase in integration among members of the European community and South Korea. But many Asian and African countries including Bangladesh, Nigeria, Pakistan, Sri Lanka and Zimbabwe are less integrated.

Chen, Buckland and Williams (2011) add to this literature by looking at the market structure dynamics of the various industrial sectors of the Chinese and Hong Kong markets in response to regulatory changes. They use a VECM-MV-GARCH model to test both the long run cointegrating vectors and short run shock transmission mechanism. They report consistently increasing conditional correlations in both long and short-term dynamics of the three markets post the equity market deregulation.

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[4]Gregory-Hansen residual, Engle-Granger and the Johansen tests have been applied.

[5]The authors combine the five markets as a principle component to graph the correlation structure with each of the five markets respectively.

[6]The data set covers both daily and weekly index prices from 1974 to 2007. But for most countries, no data were available before 1983.

Levchenko, Lewis and Tesar (2010) utilize a “wedge’ methodology developed by Cole and Ohanian (2002) to study the international trading flows into/out of the US before and after the 2008 crisis. They find a 40% reduction in both imports and exports after the crisis resulting from the extreme shocks caused by the crisis. But they do not find a role for financial variables in explaining this reduction in trade integration. Bricongne, Fontagné, Gaulier, Taglioni and Vicard (2009) report a similar decrease in trade integration for France following the 2008 crisis. More generally, Lane and Milesi-Ferretti (2010) examine the role of pre-crisis macroeconomic and financial factors to help explain the impact of the 2008 crisis across 50 countries. They find that certain macroeconomic factors such as the level of development, ratio of private credit to GDP, level of deficits and openness to trade are helpful in understanding the severity of the crisis in individual countries but find no evidence that higher financial integration pre-crisis contributed to the intensity of the crisis. In fact, they find that countries that were more financially integrated have experienced smaller economic output such as exports falls.

In contrast to the classic cointegration literature, the literature applying network methods to financial systems is much less developed. One early work is Kali and Reyes (2007, 2010)[7]utilizing a network approach to examine market correlation structure and integration in two aspects: 1)the connectivity between a country and the global trading system and 2) the impact of trade network connectedness on stock market returns during recent episodes of financial crises. They conclude that effects from the crisis would be amplified if the epicentre country were better integrated into the trade network. However, on the other hand, the well-integrated target countries affected by financial shock would, in turn, be better able to dissipate the impact.

Adarov, Kali, and Reye (2009) also examine the link between trade networks and stock market relationships. They applied a novel measure of network position termed

[7]To our knowledge, the first draft of this paper written in 2004 is the first paper in the literature of finance/economics and networks.

Random Walk Betweenness Centrality (RWBC) for a panel of 58 countries spanning the period 1990-2000. The main finding is that RWBC can both better describe a country's position in the global trade network and stock market synchronicity. The high-RWBC core countries include the UK, Germany, France, Italy, China and Japan. But some of these "core" countries experience uniformly less synchronicity in their financial markets than others.

Fagiolo, Reyes and Schiavo (2008) study the topological properties of the World Trade Web from 1990 to 2000 across 159 counties by employing a weighted network analysis (based on the exports and imports to GDP ratio of a country). They compare their weighted network to the standard binary network and show that 1) the majority of existing links are associated with weak trade relations in the weighted network but strong trade connections in the binary network; 2) the weighted network shows higher level of assortativity than the binary one[8]; and 3) the weighted network appears less clustered than the binary network and the group of countries with more active trading tend to exhibit more clustering.

Leila (2011) constructs a trade and financial network covering 61 countries and studies the effect of trade and financial integration given decreased economic output during the 2008 financial crisis. Using a distance index,[9]farness score and a centrality indicator, they find that the stronger the connection of a country in the real goods trade network to the US. They further suggest that a high correlation in the financial network helps the country to recover from crisis.

[8]They compare assortativity between a country's node degree, its average nearest node degree(ANND), the node strength and its average nearest node strength (ANNS) for both types of networks. These results are consistent for all comparison tests and it is common that a country's node degree or node strength is associated with similar level of ANND or ANNS.

[9]SeeDijkstra(1959) for the algorithm to construct the distance index.

3. Data &Methodology

3.1 Data

We collect daily stock market index prices for 57 countries (markets) covering a sample period from January 1992 to December 2012.For a country having more than one representative index, we tend to use the 'All Share' index. During the 21-year sample period, many significant financial crises occurred, which enables us to examine their effects on both regional and global market structures. To make the analysis with good readability and clarity, we partitioned the sample into sub-periods with most periods containing a regional and/or a global crisis. Thus, we subsequently identify five sub-periods: 1992-1996 (no major regional or global crisis); 1997-2000 (the Asian financial crisis); 2001-2004 (the Dot-Com bubble); 2005-2008 (the sub-prime Crisis) and 2009-2012 (the Eurozone Sovereign Debt Crisis) (see Tables 1 and 2). Although we build and analyse networks over the whole sample period, we focus our discussion of results on the last four periods because the first sub-period contains no major crisis. Geographically, we follow the natural continental locations of countries and hence consider the regions of Europe, Africa, Asia-Pacific and America.

[INSERT TABLES 1 AND 2 HERE]

3.2 Network Construction

We construct two financial networks: the Minimum Spanning Tree Network (MSTN) and Graphic Network (GN).Both contain nodes, links and other feature parameters, which are summarized in Table 3.

[INSERT TABLE 3 HERE]

Usually, nodes represent countries and can contain certain features to represent some economic meaning. For example, the nodes can be assigned with size or colour to show the economic significance. But these are no technical difficulties generally. However, when constructing links, some classic social network measurements[10]such as distance are not directly applicable to financial networks. This is because financial market trading, unlike real goods trading, is mostly accomplished through electronic platforms and would not satisfy the physical distance bound (Fagiolo, Reyes and Schiavo, 2008). We, instead, calculate correlation coefficients from the daily returns of the stock market indices and introduce importance and clustering coefficients as our network measures. We further suggest a measurable and non-negative correlation coefficient calculation to represent the inter-market distance between nodes in our network. This overcomes the issue of identifying distance in the electronic trading systems/markets and we believe this is one of the major contributions we make to the financial network literature in this paper.

3.2.1 Minimum Spanning Tree Network (MSTN) Construction

Two key components are required to construct a network: nodes and links. First, we construct links, which represent the dynamic relation between any pair of countries. First, we compute the daily log returns and standard deviation as:

$$\begin{aligned} R_{I,t} &= \ln\left(P_{I,t}\right) - \ln\left(P_{I,t-1}\right) \\ \sigma_I &= \sqrt{\frac{1}{T}\sum_{t}^{T}\left(R_{I,t} - E\left(R_{I,t}\right)\right)} \end{aligned} \qquad (1)$$

Where

I is a country index vector, which contains N country indices; N is the maximum number of countries in the sample;

$R_{I,t}$ is the return matrix of indices at time t and $E\left(R_{I,t}\right)$ is the average value of return;

$P_{I,t}$ is the price matrix of indices at time t;

σ_I is the standard deviation vector.

[10] The typical measures include farness, distance, betweeness etc. (see Adarov, Kali, and Reyes, 2009)

The correlation between countries m and n is written as:

$$\rho_{mn} = \frac{Cov(m,n)}{\sigma_m \sigma_n}, (m,n) \in I$$
$$\rho_{mn} \in Corr(I) \qquad (2)$$

Where ρ_{mn} is the correlation between country m and n ;

$Cov(m,n)$ is the covariance between country m and n ;

$Corr(I)$ is the correlation matrix contains all correlations in the sample;

The correlation matrix identifies how countries co-move over time in a visualized network. For each country, we need to select a specific correlation to represent its link to another country. Without such a specific selection, it is impossible to construct a network because one country is likely to have multiple connections to other countries based on correlations. Another reason is that when the number of links between nodes substantially increases, the network becomes 'nosier'[11]. Thus, it is more difficult to interpret and evaluate the information in the network. Moreover, the links should be non-negative distance measures but correlations could inevitably become negative.

Clearly, the selection procedure is crucial. We not only need choose the selection method but also need convert correlations into a good distance measure. In this paper, we utilize the 'the minimum spanning tree' method, which follows the principle of selecting the lowest positive values between the physical distances of two entities as the links (Gower and Ross, 1969). In our case the selected values would be the largest correlation, which is, for a country m , the largest positive correlation value from $Corr(m)$ [12].

[11] 'Noise' refers to information without important value, which would likely prevent the important information to be interpreted in the network

[12] This does not mean country m only have one correlation left. The largest correlation in other countries may still be linking to country m. After the selection, there will be $N-1$ correlations left in the network where N is the number of countries.

To covert correlation into distance, one common method is the Gower-distance measure (Mantegna, 1999), which takes lower correlations to represent longer distance as follows:

$$D(I)=\sqrt{2(1-Corr(I))} \tag{3}$$

Where $D(I)$ is the inter-market distance measure and $0 \le D(I) \le 2$ .This measure helps resolve the technical issue mentioned above because1) it is non-negative when translating correlations into length of links; 2) the more ideally, large correlations, which indicate higher significance level of connections between nodes than small ones, ought to be reflected in the network structure; 3) Gower-distance values are suitable for applying the "minimum spanning tree" procedure without necessarily changing any desirable features of the correlation values. After the process we achieve a vector of 'significant' correlations $Cor\hat{r}(I)$, and for a country m , we denote the vector of 'significant' correlations as $Cor\hat{r}(m)$.

However, Gower distance is bounded between 0 and 2 and the distance measure could be too small to see for a high correlation country. The simple and effective solution is, instead of using the Gower distance, to use the reciprocal of the correlation of a country selected from the minimum spanning tree, calculated as follows:

$$\hat{D}(I)=1/Cor\hat{r}(I) \tag{4}$$

$Cor\hat{r}(I)$, in theory, could take on zero or negative values and cause similar problem that $\hat{D}(I)$ ends up with either an indivisible problem or negative distance issue. However, to recap the principle of the 'minimum spanning tree', ensures that the correlation input to our distance measure will always be positive.

Next we turn to the construction of nodes. We use nodes not only to represent countries (stock markets) but also to reflect their economic importance level. The rationale is that the more other countries are connected to a country, the more economically important this country is. We can achieve this by building an importance coefficient (IC_m) to reflect the economic strength of country m . We consider two factors to affect this indicator: the level of connectivity and economic size.

For the former, we first let S_m be the total number of correlation links from country m and $1 \le S_m \le N-1$[13]. In theory, the number of correlation links of a country could be from 1 to 56.Note that here we only need to count the significant correlation links (S'_m) to indicate the level of connectivity. Thus, we set a threshold $\bar{\rho}_{MST}$ and count correlations that are above this threshold. $\bar{\rho}_{MST}$ is the average of all links (correlations) and can be subsequently written as:

$$
\begin{aligned}
&Threshold = \bar{\rho}_{MST} = Avg[\sum_{I}^{S_I} Cor\hat{r}(\mathrm{I})] \\
&\text{and} \\
&\mathrm{S}'_m = 1,\ldots,N-1, \forall Cor\hat{r}(m) \ge \bar{\rho}_{MST}
\end{aligned}
\tag{5}
$$

Where $\bar{\rho}_{MST}$ is the average value of all correlations in $Cor\hat{r}(I)$.

For the latter, we consider the financial strength of a country by introducing a relative market capitalization (RMC_m) measure. It is the ratio of the country's market capitalization (MC_m) relative to the total market capitalization of all countries. This measure, for country m , is represented by:

$$
RMC_m = \frac{MC_m}{\sum_{m}^{N} MC_m} \tag{6}
$$

Where MC_m is the market capitalization matrix of country m .

[13] In our case, S_m is between 1 and 56. The number is not always being 56, because before 2005 data are not available for some countries, such as Egypt, Saudi Arabia, and South Africa etc. Note that, for simplicity, we assume that the links that have been included in the MSTN are the 'only' linkages between nodes that are actually connected. This is due to the fact that, in a correlation network as long as a correlation value between two entities is non-zero, there could be a link. Such an assumption is generally applied in the network literature and we therefore, assume the linkages that are selected for our MSTN are the unique linkages between two country nodes.

We now can finally obtain the importance coefficient through the product of these two components:

$$IC_m = S'_m * RMC_m \tag{7}$$

This importance coefficient is also able to reveal potential co-movements between countries. The underlying assumption is that countries that are highly correlated to other countries tend to share co-movements with them (Agmon, 1972).Usually, such countries would have more significant influence financially and may consequently lead to their pre-dominance in the regional financial environment. It is well established that larger financial markets often attract more international financial investments due to their open economic environment, lower trade barrier, culture, expertise etc. (Demirgüç-Kunt and Levine, 1996; Krugman, P. 1998; Bevan, Estrin and Meyer, 2004); and such a market would be more likely act as the regional financial powerhouse or driver.

3.2.2 Graph Network (GN) Construction

Identifying the links in a Graph network is more straightforward than in a MSTN. Using the correlations between markets from the results of equation (2), we rank all correlations and select the top, say 1%, 5%, 10%, 20%, 30% and/or 50%, correlations to determine the links and hence the networks.[14]In contrast to MSTN, GN does not require all countries in the network to be linked, but only those contributing significantly to clustering effects.

The reason to use different percentages to select links is to reveal clusters in our global financial network. With a small percentage of links, we aim to identify the core countries in forming a clustering. But, when the percentage filter increases, we expect more countries to appear in the cluster so that we can achieve a better understanding of the formation of clusters.

[14]A percentage is not necessarily required if the links can reach the maximum number. This is because most of the nodes do not have identical number of links. However, in correlation-based networks, such a condition is almost impossible and we, therefore, apply relatively small percentages as a proxy to capture small clusters.

The clustering coefficient was initially introduced to networks, especially social networks, to identify small knit groups with a heavy density of links (Holland and Leinhardt, 1977). We follow Watts and Strogatz (1998) and calculate the clustering coefficient (CC_m) of country m, which measures the contribution of this country to a cluster and implicitly indicates how countries cluster within the network. It is written as:

$$CC_m = \frac{2\Delta_m}{N(N-1)} \tag{8}$$

Where Δ_m is the 'degree' of a country, which is the number of links connecting with country m ; N is the number of countries that have been included in our network[15].

Empirical Results

We use both MSTN and GN to identify the dynamics of long-run co-movements among stock markets. More specifically, we investigate 1) whether the global market tends to share co-integrated trends; 2) the connectivity among countries; 3) the dynamics of country clustering that whether countries are moving together or away from one another; and 4) centrality of the clustering in the regional and global networks. The MSTN has particular advantages in answering the first two questions and GN for the last two. Clusters in the GN are usually bounded into geographic regions but could contain countries from other continents. Further, we find evidence of bridge countries connecting different clusters from both the GN and MSTN visualizations.

For the GN, we present results from the 1% and 10% networks, which are representative. As explained above, the 1% GN network may not reflect all clusters

[15]The clustering coefficients provide information on which countries contribute more greatly than others to a cluster and, in a dynamic context, how the small group clustering has emerged.

worldwide because a small number of countries will be selected into it. But the advantage is that countries appear in this network will have a high-level of connectivity and consequently reveal the most significant clusters and the centrality of such clusters. In contrast, the 10% network allows for a more flexible selection process, more clusters may be picked up and more countries appear in them. We also find that the sizes of the cluster in the 10% GN are bigger and small clusters are more likely to merge into a large one. In the 10%GN, countries outside of a cluster are usually scattered around and some countries such as Australia and Japan become bridge countries between geographical clusters. In addition, the emergency, decomposition and structure are not only sensitive to the selected percentage filter but also to the time period. For example, during the 2005-2008 period, the US lost its centrality of the regional cluster during the development time of the liquidity crisis in 2006 and 2007. Towards to 2008 when the Lehman case became clearer to the market, the US recovered its central position in the local cluster (see Figure 2, Panel (c) and Table 5).

In comparison to the GN, the MSTN is more dynamic reflecting the structural changes in the interconnection of the nodes contained in the network through the years. The changes are visibly captured by both the length of linkages from each country to other countries and the size of the country nodes. In the global MSTN, we are able to analyse both regional and global features and identify the dominant countries in terms of the significance of their importance coefficient. The dynamic change in connectivity and significance levels of countries are also informative in identifying the impact of financial crises on integration. Looking at the 2005-2008 period again in the MSTN, not only the US has different paths (direct or indirect) and length to countries such as Canada, France and Mexico, its capital sizes change along with market events such as the announcement of Lehman Brothers failure. One possible economic interpretation for this could be that the Lehman's default led to shrinkage in the economic wealth of the US stock market, which further caused contagion harming the market confidence. The close partner countries would be the ones affected most and hold highest level of fear in investing in the US market (see Figure 1, Panel (c)).

The modern global financial system is complex and the two networks we use in this paper help us better understand the system dynamics and identify interesting results that have not appeared in the literature. For example, we find Japan has been the most important country globally during certain periods but is not identified as the financial centre in the local (Asia-Pacific) cluster. Another finding is that both the MSTN and GN visualizations show that the US detached from the Europe cluster post the recent 2008 financial crisis. In addition we find Australia, although geographically close to the Asia-Pacific region, is more strongly connected to the sub-group of Europe. These new findings provide more scope for researchers and policy makers to better understand the new global financial geography portrayed in Krugman (1998).The main results of MSTN are in Table 4 containing the importance coefficients (ICs) in Panel (a) and rankings in Panel (b). The corresponding visualized results are presented in Figure 1. For GNs, Table 5 reports Clustering Coefficients (CC) and Figure 2 shows the visualization at both 1% and 10% significant levels.

[INSERT TABLES 4AND 5 HERE]

[INSERT FIGURES 1 AND 2HERE]

We examine the results through the four time periods and across the continental regions of Europe, America, Asia-Pacific and Africa. In the European region, the UK has consistently been the most important market (ranked second globally ahead of France and Germany), apart from 2011 in which it is ranked fourth globally. However, the UK has not been the sole leader in the European region since 1996[16] as France and Germany are close behind in terms of importance coefficients. We, therefore, characterize the European regional network as being a three-centred network with the

[16]The 1992-1996 period results show that the UK had been the solo leading power in driving the European economy.

UK being fractionally ahead most of the time. The formation of Eurozone in 1999 could provide explanations for the growth of importance in France and Germany and the emergence of this joint power pattern in Europe. Another observation is that, in the 1% GN, more countries such as Italy and Spain within the European Union appeared. The results from the clustering coefficients further support the argument of joint leadership within the European region as we constantly see the UK, France and Germany exist in clustering (see Figure 2). This multi-country core-power group dynamics can be further backed up by the centrality statistics in Table 5. For example, in 1997, 2001, 2009 and 2011-2012, the UK was not the most dominant country in the cluster. Instead, various countries including Spain, Italy, Sweden, Switzerland and Netherlands appeared in the power group. Further, Switzerland and Spain have entered/re-entered into the significance group and rankings in three out of four periods suggested by the ICs in Table 4 Panels (a) and (b). To echo our crisis argument, the appearance of Netherlands in the significant group for the 2009-2012 period supports the notation that the central European markets (as opposed to peripheral European markets) have been less affected by both the 2008 global crisis and 2011 Eurozone Sovereign Debt crises.

In the America region, the US has been prominently and consistently the financial centre and the driver for the global economy by its significant importance coefficients and ranks (see Table 4, panels (a) and (b)). This importance continues after 2008 despite doubts regarding the US economy growth and recovery post the crisis. In contrast, the clustering coefficients of the American regional cluster present a different picture in that the US has only been the continental financial centre from 2010 to 2012. Other countries such as Canada etc. have demonstrated centrality although in an inconsistent manner. One reason for this could be that the US economy regained attraction to the neighbour countries after the 2008 crisis due to its size, impact and ability of self-recovery. During the rest of the three periods in our sample, emerging countries such as Brazil, Mexico and Peru have seen rapid growth in their economies, thus, forming a centrality concentration through attraction of foreign investments. In addition, Canada has long been another important country in this continent although it has been known for its conservative policy orientation and slow GDP growth. Overall, for this region the centrality concentrates on a single country in contrast to the multi-country centrality in Europe.

In the Asia-Pacific region, Japan is the only country appearing in the top five significant countries in the MSTN results for some of the periods and years (2000 and 2004-2006). From 2004 to 2006, Japan experienced a phase of being a significant market in the global network. Its importance overtook that of Germany in both 2005 and 2006. However, the clustering coefficients from 1996 to 2012 do not support Japan being the centre of the regional economy cluster. Similar to the single-country dominance in the American region, the centre of the Asia-Pacific cluster has moved between Hong Kong and South Korea although Hong Kong remains the most significant centre most of the time. South Korea was the centre in 2003, 2004, 2008 and 2012. Japan has, surprisingly, never become the financial centre of the region. But if we observe the Figures 1& 2 closely, we can see that Japan tends to serve as a bridge country to connect the Asia-Pacific countries to other regions. Australia, although possessing no significant importance coefficients, also acts as a bridge country and this could be due to its geographical distance from the rest of the region.

For Africa, no results are reported in Tables 4 and 5 because there were no countries identified to be significant in the IC test or centres detected in the continental clusters during the sample period. Figure 1 shows that the majority of African countries are respectively linked to other regions and this could associate with its strong trade links to the rest of the world but slowly growing financial markets relative to the global market. From panels in Figure 2, there is no evidence of clustering effects within the Africa region. Instead, African countries usually attach to other clusters or scatter outside a cluster individually. This could be affected, again, by its geographical and economic disadvantages. Although South Africa, the primary economically significant country in Africa, has connections with the US and European countries economically and financially, it appears in significant in both MSTN and GN. This could be because that both IC and CC measures fully or partially depend on the number of significant links that a country possesses and the African countries including South Africa have a relatively lower level of such linkages and the results are therefore diluted. Also, it is generally believed that the economic growth in Africa relies on multiple factors such as labour, financial resources, regulations etc. more collectively (King and Levine 1993;Enisan andOlufisayo2009). Hence, even if South Africa has financial connections with many countries within Africa, its importance could be diluted by its connections to other regional clusters. Moreover, the rest of Africa may not be active financially. Hence, it may not lead to a formation of a cluster centred in South Africa in the local network.

Globally, the MSTN in Figure 1 shows that Europe has constantly been the most integrated region in terms of both concentration and size of the cluster in the world[17]. This is because Europe's average correlation value is higher than the global average (see Figure 3) and there are more links from the European country nodes selected into the MSTN following from the minimum spanning tree selection process above the threshold level.

With the launch of Euro at the beginning of 1999, it would be natural to expect the European countries to have become more correlated. However, Figure 3 shows that the threshold of the EU region actually fell from 0.621 in year 1998 to 0.522 in year 1999. This could be driven by the decrease in correlation of the global network by roughly 0.1. It implies that the drop could be connected to spillovers of exogenous shocks from the Asian Finance Crisis rather than endogenous information from the emergence of the new currency. The importance coefficients in Table 4 further demonstrate that Europe has become more integrated. In contrast, the America's

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[17]The Europe cluster consists mainly of European countries excluding some east European countries like Russia, Hungary and Poland etc. The Asia cluster contains the Asian excluding some west Asian countries such as Israel, Indonesia, India and Saudi Arabia etc.

average correlation remains nearly static and both Asia-Pacific and Africa's are below the world average.

[INSERT FIGURE 3 HERE]

When observing the MSTN in Figure 1 around the 2008 financial crisis, it clearly shows that countries that are close in distance to one another in 2008are much further apart in 2009. During the crisis period, the direct linkage between the Europe region and the America region reduced from 0.79 to 0.67 but moved back together again after 2009. If we observe the trend of the threshold of correlations in MSTN (Figure 3), we also see a similar pattern. This change implies that the strength of interconnections (or betweeness) among countries reached its zenith during the peak of the crisis but was weakened sharply in 2009, followed by a slower descending trend in the later years. We also find similar results in times of other financial crisis events. Around the 1997 Asian financial crisis the direct link between the Asian region and other regions was reduced from 0.63 to 0.55 and back to 0.6 in 2000. During the dot com bubble, the connection between the America region and others reduce from 0.63 to 0.49 and from Figure 1 and Figure 2 we can clearly see the countries in the America continent are not inter-connected with each other. Such a conclusion can be further supported by the dynamic trend of the global threshold in Figure 3.

Conclusion

This paper applies two correlation based network approaches, MSTN and GN, to a range of 21 years of panel data. With these two networks we provide a visualized and dynamic network structure of the world financial system. In terms of improvement to previous network methods in finance our methods do not rely on a real goods trading system to provide any distance measures. Using two correlation based networks to complement each other we are able to gather more information for network analysis.

Additionally, we provide a visual representation of both networks in order to demonstrate easier interpretation of changes over time.

The empirical results reported are similar to those reported in previous literature. We find a general tendency of markets to become more integrated over time. Further, there are three clear clusters formed continentally (Europe, America and Asia-Pacific) in the global financial system. The Africa region does not have any regional clusters but is scattered and linked to the three clusters listed above individually. Over time all clusters become more integrated within their region and become more connected with each other.

In terms of dominant markets/country regionally or globally, our results suggests that the US is the dominant country in the global financial network. But, at the regional level, we find some different results from those reported in previous studies. The America and Asia regions both have clear dominant countries: the US and Hong Kong. In the Asia region Japan possesses the highest importance but it could not be considered a centre of the region but more of a bridge country that links the region with other clusters. The Europe region provides more interesting results, despite previous literature were showing the UK as the sole dominant power in the Europe, our results suggest that after 1996 the region has multiple important centres and not solely the UK. Africa, possibly due to its late economic emergence, does not appear to form strong clusters to link to other continents. In contrast, individual African countries form economic connections with their own selected markets. Another key finding of this paper is that during a crisis period there is a general tendency for countries to move away from the crisis origin country only to then move back after recovery from the crisis. This effect is clearly revealed by the visualized MSTN and supported by the average correlation values.

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Appendix

Table 1: Timeline of Financial Crises between 1992 and 2012.

The table provides the timeline of financial crises between 1992 and 2012. Most crises outlined are regional. For the purpose of our network study, we mainly focus on the global crises and use these events to separate time periods in order to capture the financial network structure changes.

Period	Year	Events	Scale
1992-1996*	**1992**	Black Wednesday (September 16, 1992)	Regional (the UK); The estimated loss is $3.3 billion according to Freedom of Information Act.
	1994	Mexico Peso Crisis (December, 1994)	Regional (Mexico); The estimated bailout amounts to $50 billion.
1997-2000	**1997**	1997 Asian Financial Crisis (July, 1997)	Continental (Asia) to worldwide; It spilled across more than 10 countries and worldwide. It also triggered the 1998 Russian Crisis.
	1998	The Argentine Great Depression (1998-2002)	Regional (Argentina); The estimated debt default is $132 million.
	1998	Russian Financial Crisis (August 17, 1998)	Regional (Russia); The estimated rescue package is $22.6 billion from the IMF and World Bank.
2001-2004	**2001**	Turkish Crisis (February 19, 2001)	Regional (Turkey); The estimated loss is $5 billion.
	2001	Dot-Com Bubble (2001-2002)	Global. The estimated loss during the period approximates $5 trillion. During this period, the 9/11 terrorist attacks also disrupted the US stock market.
2005-2008	**2006**	Sub-primary Financial Crisis (2006-2008)	Global. Since the burst of the housing bubble in 2006, the prominent events include the bankruptcy of Lehman Brothers on September 15, 2008 and Northern Rock collapse in mid-September, 2007. The contagion effects have caused a banking boom, commodity boom and eventually a systematic financial collapse worldwide.
2009-2012	**2009**	Eurozone Sovereign Debt Crisis (2009-2012)	Continental to worldwide; The Greek debt is estimated over $400 billion. The money injection exceeded $240 billion. The contagion spilled across the entire Europe and even internationally.

*To be concise, Period 0 results are not reported as only regional but not global crises occurred. These results are available on request.

Table 2: Country Description.

This table provides the information of countries, country indices and their abbreviations by regions. There are 57 included and the selection of country indices aim to represent the full market: for example, we pick the FTSE ALL SH instead of FTSE 100. The data are collected from DataStream^{TM}.

Region	Country	Index	Abb.	Region	Country	Index	Abb.
Europe	Austria	Austria Traded Index (ATX)	AT	**Asia- Pacific**	Australia	ASX All Ordinaries	AU
	Belgium	Belgium Stock Market (BEL 20)	BE		Bangladesh	Bangladesh SE All Share	BD
	Denmark	OMXC20	DK		China	Shanghai SE A Share	CN
	Finland	Finland Stock Market (HEX)	FI		Hong Kong	Hang Seng index	HK
	France	CAC 40	FR		India	India BSE 100	IN
	Germany	DAX 30	DE		Indonesia	IDX Composite	ID
	Greece	Greece Stock Market (ASE)	GR		Israel	Israel TA Stock Exchange (ISTA100)	IL
	Hungary	Budapest (BUX)	HU		Japan	Tokyo Stock Exchange	JP
	Iceland	Iceland All Share (OMX)	IS		South Korea	Korea SE Composite (KOSPI)	KR
	Ireland	Ireland Stock Market (ISEQ)	IE		Lebanon	Lebanon BLOM	LB
	Italy	MSCI Italy	IT		Malaysia	MSCI Malaysia	MY
	Luxembourg	Luxembourg Stock Exchange	LU		Oman	MSCI Oman Domestic	OM
	Malta	Malta Stock Exchange (MSE)	MT		Pakistan	MSCI Pakistan	PK
	Netherlands	Netherlands Stock Market (AEX)	NL		Philippines	Philippine Stock Exchange (PSEi)	PH
	Norway	Norway Stock Market (OBX)	NO		Qatar	MSCI Qatar	QA
	Poland	Poland Stock Market (WIG)	PL		Saudi Arabia	Saudi Arabia Stock Market (TASI)	SA
	Portugal	Portugal PSI General	PT		Singapore	Straits Times Index	SG
	Romania	Romania BET	RO		Sri Lanka	Colombo SE All Share	LK
	Russia	Russia Stock Market (MICEX)	RU		Taiwan	Taiwan SE Weighed (TAIEX)	TW
	Spain	Spain Stock Market (IBEX 35)	ES		Thailand	MSCI Thailand	TH
	Sweden	Sweden Stock Market (OMX)	SE	**America**	Argentina	Argentina Stock Market (MERVAL)	AR
	Switzerland	Switzerland Stock Market (SMI)	SZ		Brazil	Brazil Stock Market (IBOV)	BR
	UK	FTSE All Share	GB		Canada	TSX Composite	CA
Africa	Egypt	Egyptian Exchange 30 (EGX 30)	EG		Chile	Chile Santiago SE (IGPA)	CL
	Kenya	Kenya Nairobi SE	KE		Jamaica	Jamaica SE Main Index	JM
	Mauritius	MSCI Mauritius	MA		Mexico	Mexican Stock Exchange IPC35	MX
	Morocco	Morocco All Share (MASI)	MU		Peru	Lima SE General (IGBL)	PE
	Nigeria	MSCI Nigeria	NG		USA	S&P Composite	US
	South Africa	MSCI South Africa	ZA				

Table 3: MSTN and GN Construction Description.

This table summarizes the construction description and features of both MSTN and GN. In comparison, we conclude that the nodes and links in the MSTN carry meaningful information but only nodes represent the clustering features in the graphic network.

	MSTN	***GN***
Nodes	Countries	
Links	Correlations between two linked countries	
Length of Links	Values of Correlations	n/a
Size of Nodes	Importance coefficient of a country	Clustering coefficient of a country

Table 4: Important Coefficients (IC)and Rankings of the Global MST Network.

Panel (a): This panel summarizes the Importance Coefficients of the global MST network. We report the top five important markets out of fifty-seven countries in each four-year period. The countries, which are highlighted with *, are the ones that have not constantly remained in the ‘top five’ range during that period. The.US, GB, DE and FR always remain the most significant countries. DE and FR often swap their rankings. The US always remains the most significant country and GB stays in second place apart from 2011. From 2004, JP not only reappeared (after first appearing in 2000) in the significance group but also improved its ranking to number 4 until 2006, which is highlighted with * and in italic.

Country	IC	Country	IC	Country	IC	Country	IC
1997		**1998**		**1999**		**2000**	
US	509.45	US	605.97	US	899.28	US	816.51
GB	287.77	GB	363.66	GB	475.71	GB	371.49
DE	133.83	DE	167.55	FR	225.99	FR	195.51
FR	85.06	FR	151.86	DE	206.46	DE	194.56
*SZ**	82.93	*SZ**	111.77	*NL**	106.48	*JP**	113.78
2001		**2002**		**2003**		**2004**	
US	499.31	US	999.92	US	1542.44	US	588.29
GB	292.55	GB	268.74	GB	398.96	GB	456.68
FR	179.88	FR	156.81	FR	219.91	FR	238.81
DE	154.51	DE	105.85	DE	165.27	*JP**	198.84
*SZ**	84.57	*SZ**	84.63	*ES**	111.23	DE	182.96
2005		**2006**		**2007**		**2008**	
US	611.62	US	1925.26	US	898.61	US	423.01
GB	468.41	GB	820.46	GB	730.05	GB	367.08
FR	237.69	FR	481.38	FR	574.27	FR	282.35
*JP**	170.7	*JP**	255.49	DE	360.43	DE	199.65
DE	165.05	DE	236.1	*ES**	291.93	*ES**	161.96
2009		**2010**		**2011**		**2012**	
US	1901.82	US	2933.97	US	2677.49	US	3195.78
GB	529.1	GB	671.85	FR	339.21	GB	625.71
FR	390.89	FR	381.86	DE	281.58	FR	377.84
DE	257.2	DE	270.51	GB	256.12	DE	294.61
*ES**	257.13	*SZ**	221.52	*ES**	176.48	*SZ**	174.99

Panel (b): This panel reports the average IC ranking scores of each country in each four-year period and its position change. In each period, we score the countries in the list from top to bottom5, 4, 3, 2 and 1. If a country does not appear in the list for a specific year (e.g. SZ in 1999), it scores 0. We, then, calculate the average ranking score for each country in each period and report them in the panel. We also observe the countries' ranking shift within each period when they appear in the list. The US, GB, DE and FR constantly remain top four significant countries throughout the whole sample period although some of the individual rankings shift occasionally. SZ, NL, JP and ES more often disappear and/or reappear in the list. Usually, these countries rank behind those four most significant countries when they appear and remain in the list. However, JP overpowered DE and ranked number 4 from 2004 to 2006. Overall, the most significant countries tend to be the US and European countries apart from JP.

Country	**Period**	**Average IC Ranking Score**	**Ranking Shift?**	**Country**	**Period**	**Average IC Ranking Score**	**Ranking Shift?**
US	1997-2000	5	N	**SZ***	1997-2000	0.5	N
	2001-2004	5	N		2001-2004	0.5	N
	2005-2008	5	N		2005-2008	0	-
	2009-2012	5	N		2009-2012	0.5	N
GB	1997-2000	4	N	**NL***	1997-2000	0.25	-
	2001-2004	4	N		2001-2004	0	-
	2005-2008	4	N		2005-2008	0	-
	2009-2012	3.5	***Y***		2009-2012	0	-
DE	1997-2000	2.5	***Y***	**JP***	1997-2000	0.25	-
	2001-2004	1.75	***Y***		2001-2004	0.5	-
	2005-2008	1.5	***Y***		2005-2008	1	N
	2009-2012	2.25	***Y***		2009-2012	0	-
FR	1997-2000	2.5	***Y***	**ES***	1997-2000	0	-
	2001-2004	3	N		2001-2004	0.25	-
	2005-2008	3	N		2005-2008	0.5	N
	2009-2012	3.25	***Y***		2009-2012	0.5	N

Table 5: Clustering Coefficients from the Graph Networks.

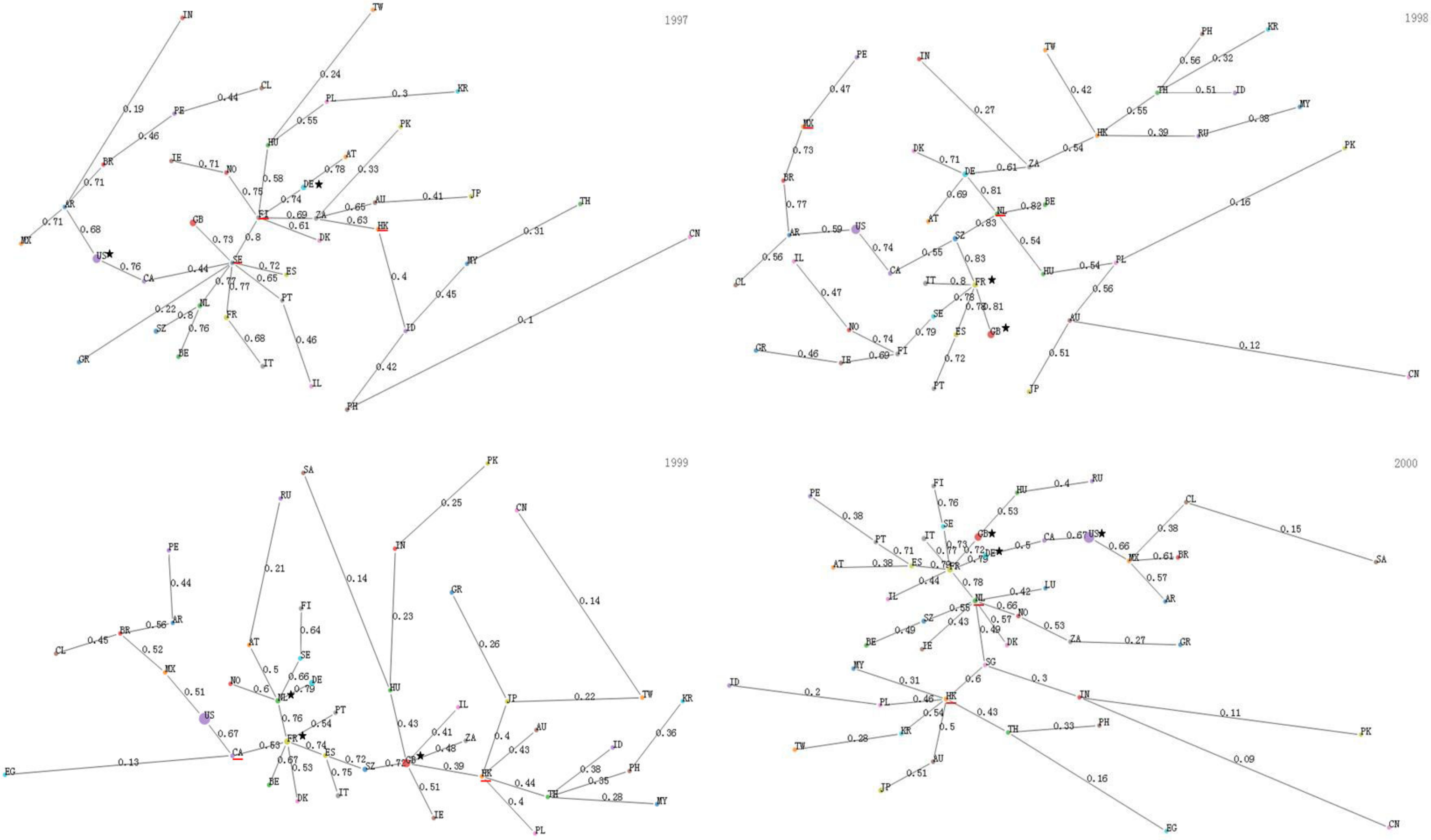
This table reports the most significant clustering coefficients from the Graph Networks at 1% and 10% by region. In the continent of America at 10%, the US and CA dominate the clustering unless some emerging country like MX and BR took over. In Asia at 10%,HK and KR clearly show centrality in the regional economy in turn with HK being the most significant centre in the region in most of the periods. In Europe, there tends to be multiple markets forming clusters collectively at both 1% and 10% and FR, DE, GB, NL and ES usually s dominate the clustering. When comparing the 1% with 10% clusters, the components of each cluster may be different.

Region	1%		10%		1%		10%		1%		10%		1%		10%	
	Country	CC	Country	CC	Country	CC	Country	CC	Country	CC	Country	CC	Country	CC	Country	CC
	1997				1998				1999				2000			
America	US	0.001	US	0.004	-	-	MX	0.002	-	-	CA	0.006	-	-	US	0.004
Asia	-	-	HK	0.001	-	-	-	-	-	-	HK	0.001	-	-	HK	0.006
	SE	0.005	FI	0.019	IT	0.007	FR	0.016	FR	0.004	NL	0.018	FR	0.006	NL	0.015
Europe	NL	0.004	DE	0.017	NL	0.005	NL	0.016	ES	0.004	FR	0.017	DE	0.003	DE	0.014
	SZ	0.003	SE	0.017	SZ	0.005	GB	0.016	NL	0.003	GB	0.017	IT	0.003	GB	0.013
	2001				2002				2003				2004			
America	-	-	CA	0.006	-	-	CA	0.006	-	-	US	0.009	-	-	MX	0.006
Asia	-	-	HK	0.003	-	-	HK	0.002	-	-	KR	0.004	-	-	KR	0.005
	FR	0.006	FR	0.016	FR	0.006	FR	0.015	FR	0.006	NL	0.016	FR	0.005	FR	0.014
Europe	NL	0.006	NL	0.016	NL	0.005	SE	0.015	NL	0.005	FR	0.015	DE	0.005	BE	0.014
	IT	0.003	GB	0.014	GB	0.002	IT	0.014	ES	0.003	ES	0.014	NL	0.004	DE	0.014
	2005				2006				2007				2008			
America	-	-	US	0.003	-	-	BR	0.003546	-	-	MX	0.004	-	-	US	0.003
Asia	-	-	HK	0.004	-	-	HK	0.003546	-	-	HK	0.004	-	-	KR	0.003
	FR	0.006	GB	0.014	FR	0.006	SE	0.014184	FR	0.006	NL	0.013	FR	0.006	GB	0.014
Europe	DE	0.004	FR	0.013	NL	0.004	GB	0.013298	NL	0.004	FR	0.012	GB	0.004	SE	0.014
	NL	0.003	NL	0.013	DE	0.004	AT	0.013298	GB	0.004	GB	0.012	IT	0.004	FR	0.013
	2009				2010				2011				2012			
America	-	-	US	0.006	-	-	US	0.003546	-	-	US	0.003	-	-	US	0.006206
Asia	-	-	HK	0.001	-	-	KR	0.000887	-	-	HK	0.001	-	-	KR	0.003546
	FR	0.005	FR	0.015	FR	0.005	BE	0.014184	FR	0.005	FR	0.014	FR	0.005	BE	0.015071
Europe	DE	0.005	NL	0.013	NL	0.004	FR	0.013298	NL	0.004	NL	0.014	NL	0.005	NL	0.015071
	NL	0.004	ES	0.013	GB	0.004	GB	0.013298	DE	0.003	GB	0.013	BE	0.003	DE	0.015071

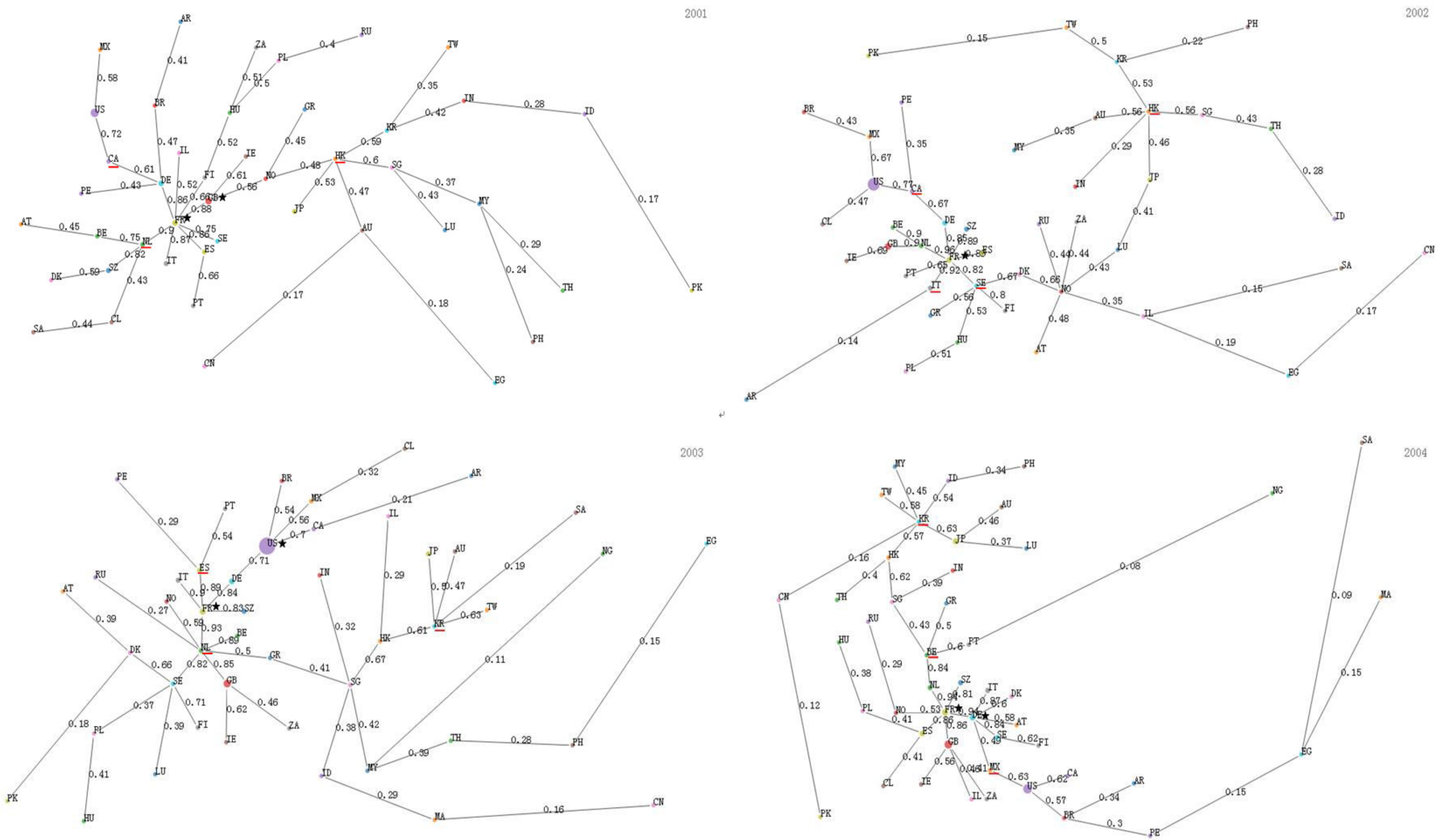
Figure 1: Visualized MST Networks

The countries marked with star indicate the countries possess both high IC and CC, the red underlined countries are only high in CC values but not in IC values.

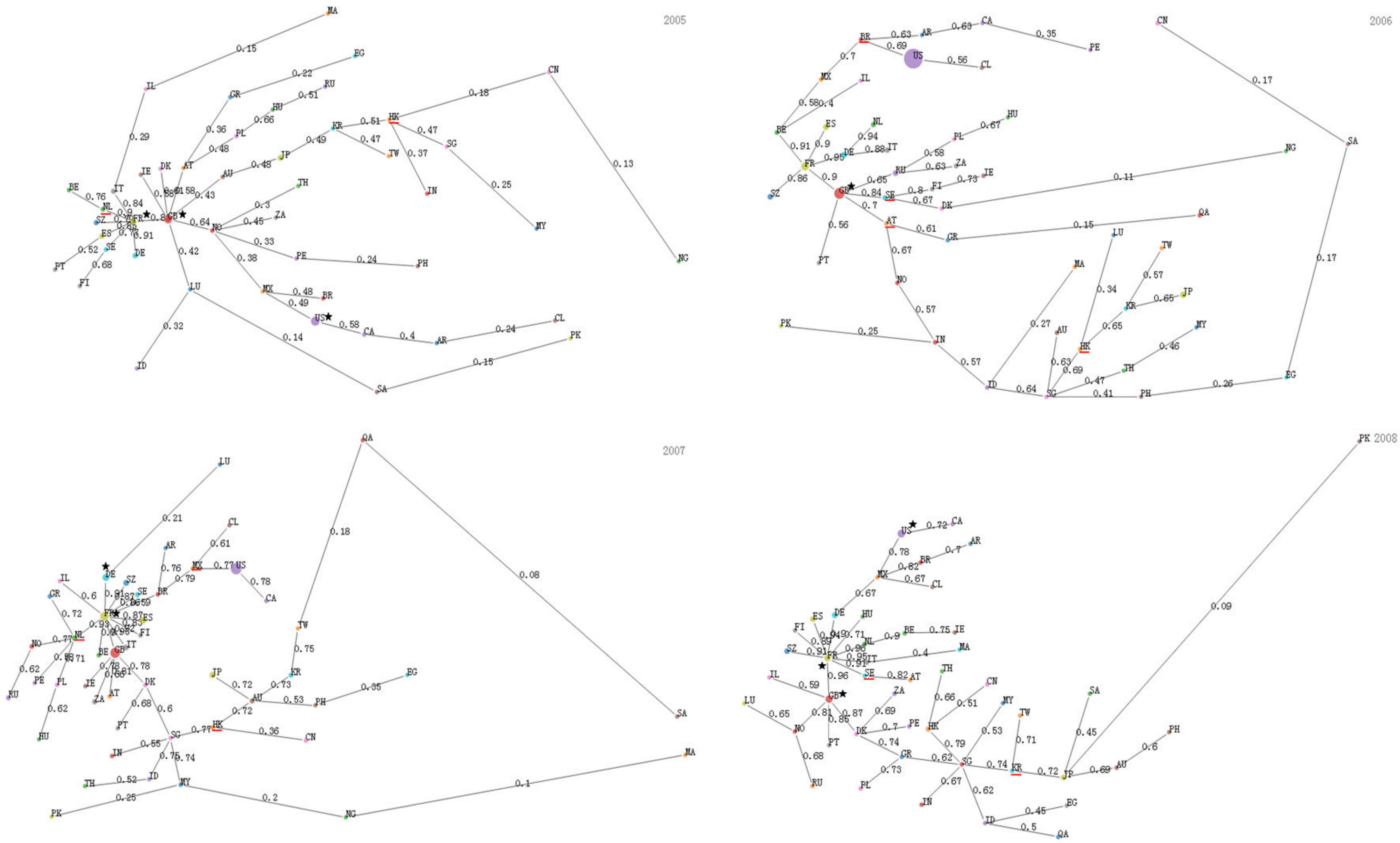
Panel (a): 1997-2000 Period



Panel (b): 2001-2004 Period



Panel (c): 2005-2008 Period



Panel (d): 2009-2012 Period

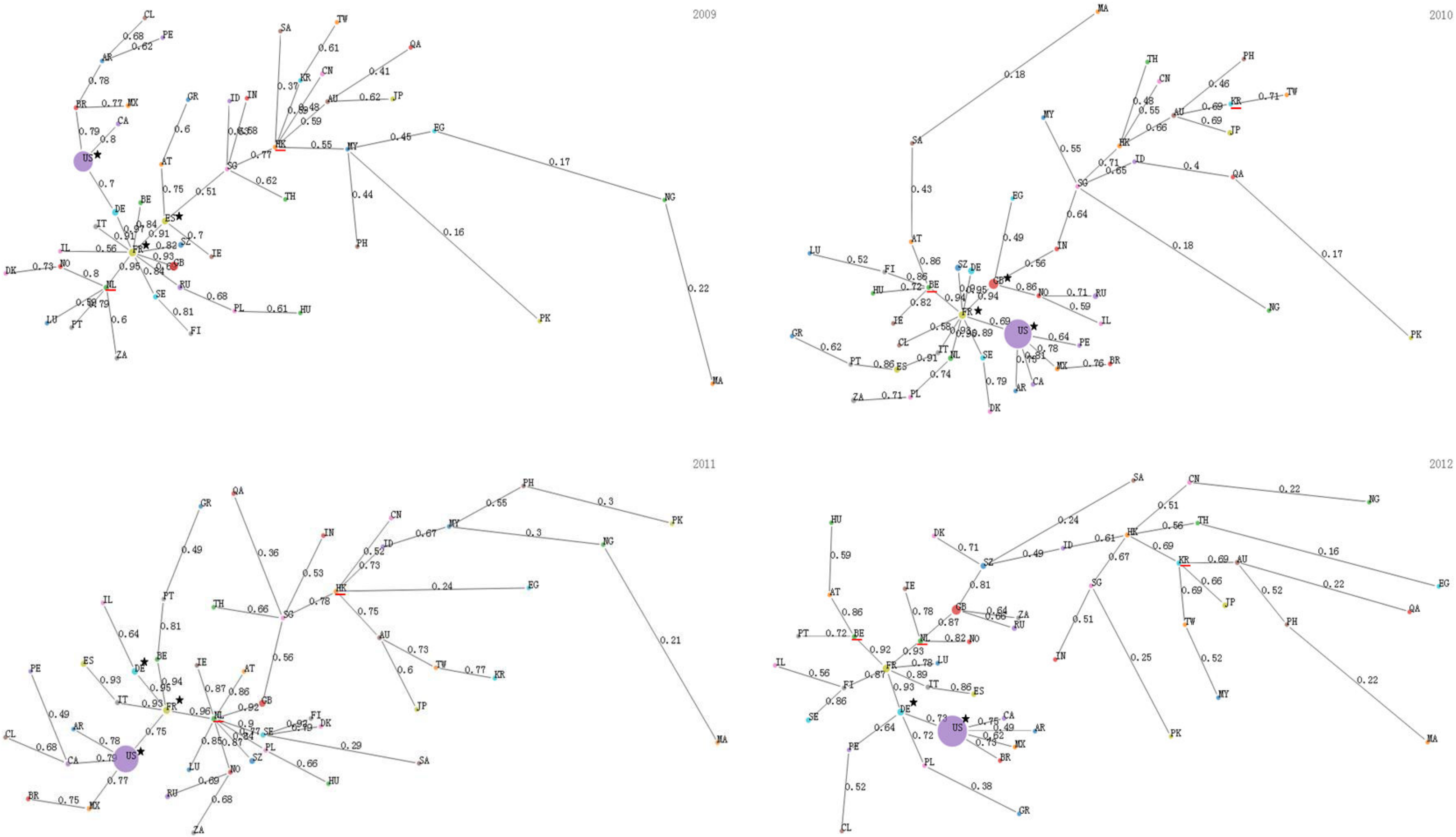
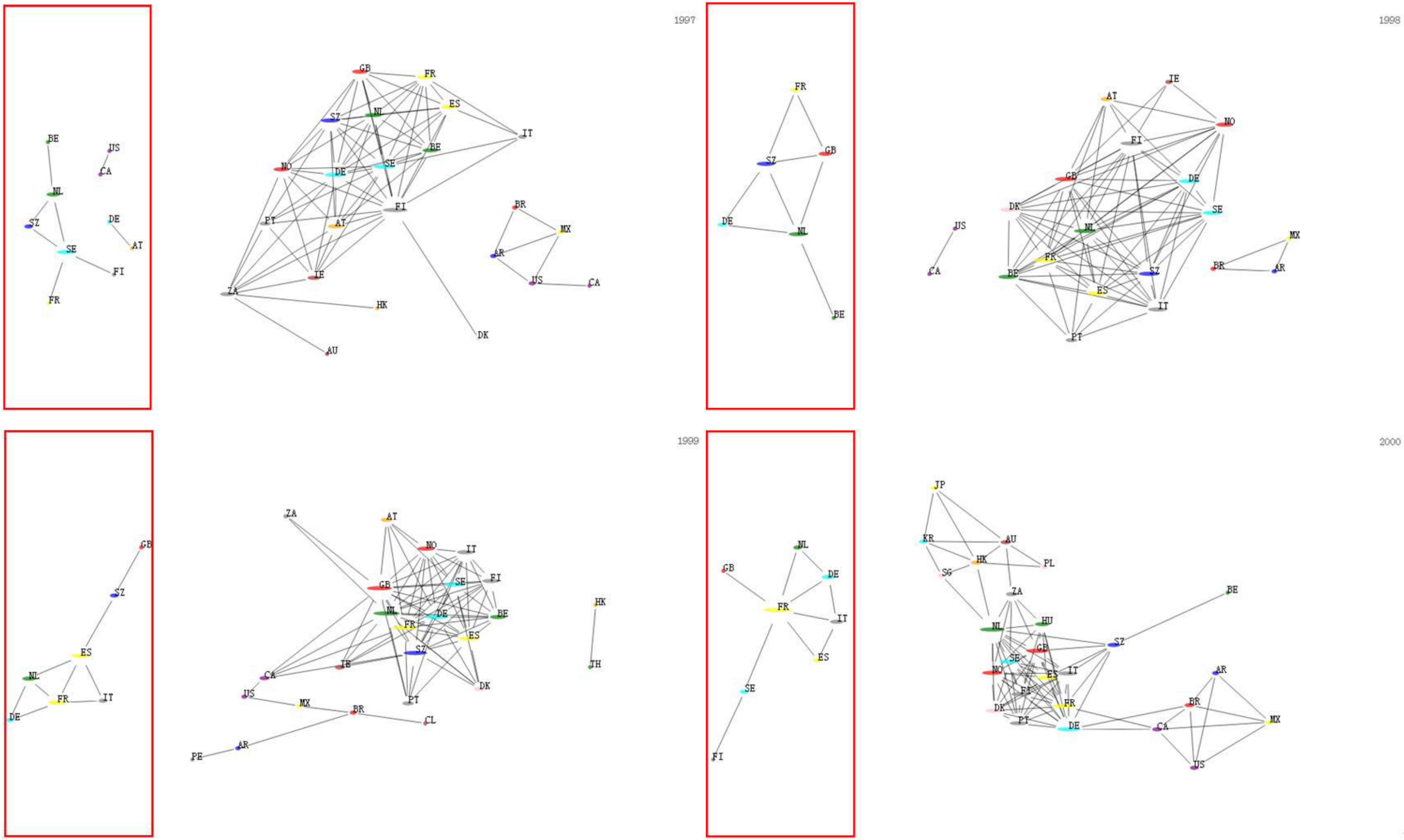


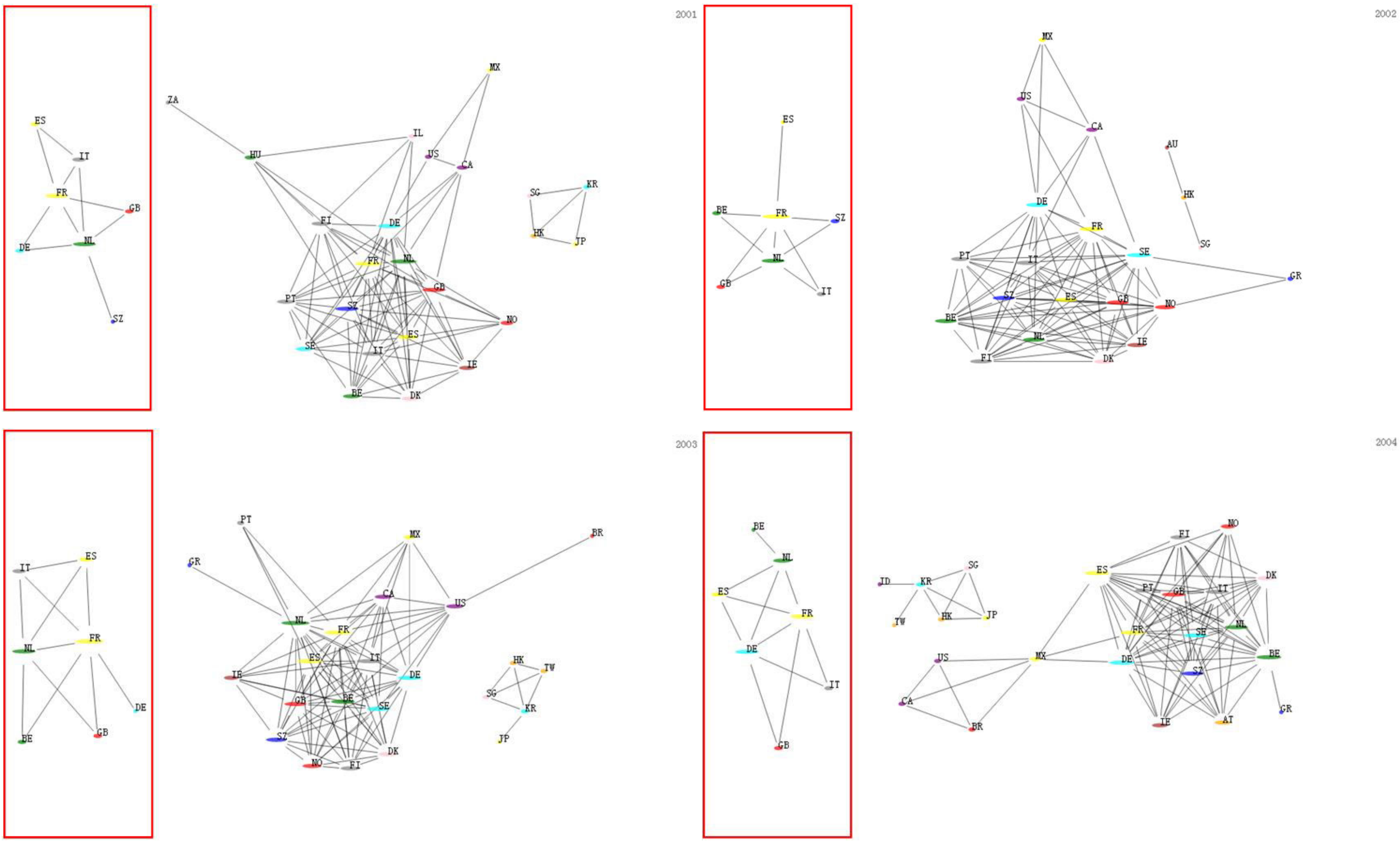
Figure 2: Visualized Graph Networks[18]

Panel (a): 1997-2000 Period

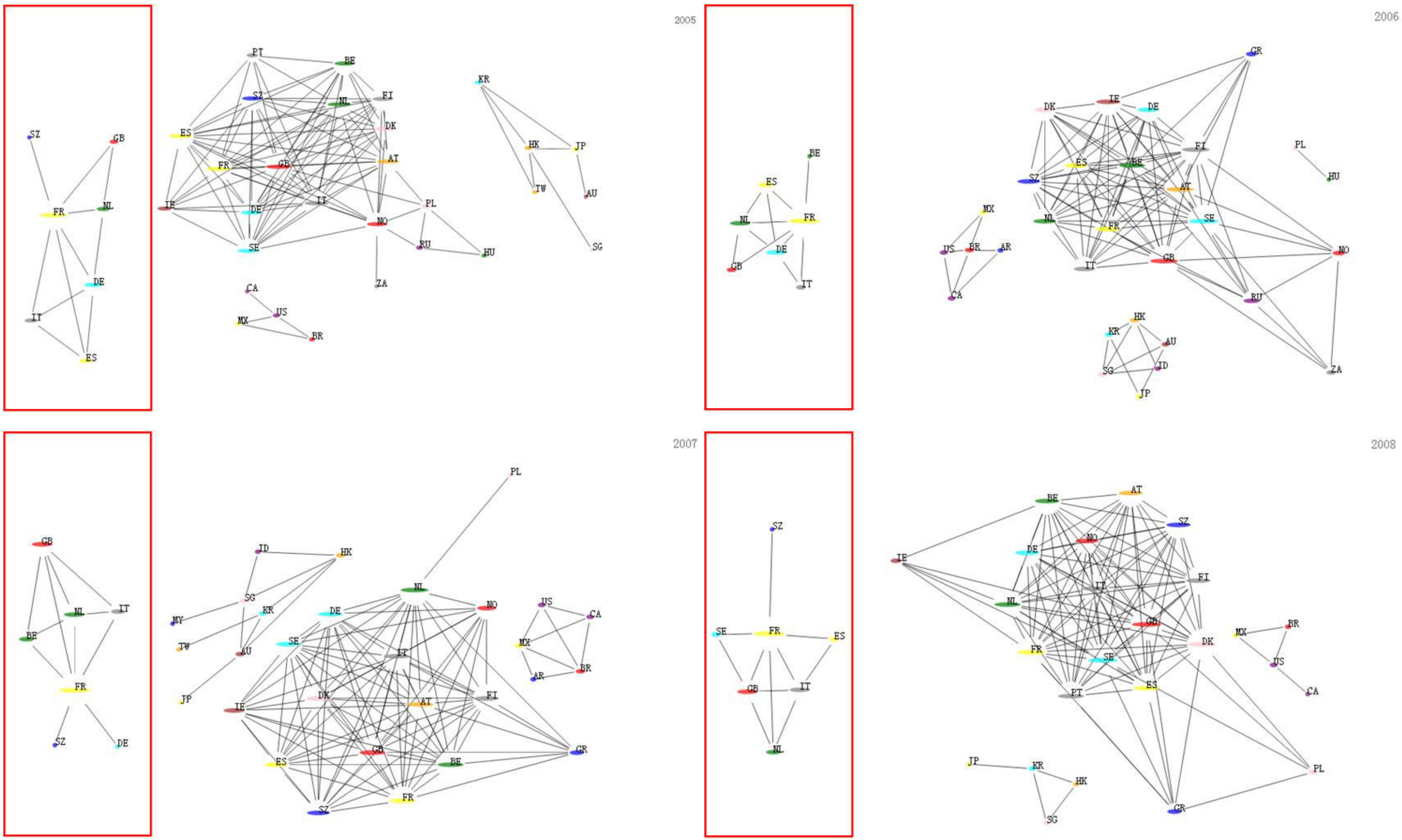


[18] The pictures marked with red rectangle border are from 1% graph network.

Panel (b): 2001-2004 Period



Panel (c): 2005-2008 Period



Panel (d): 2009-2012 Period

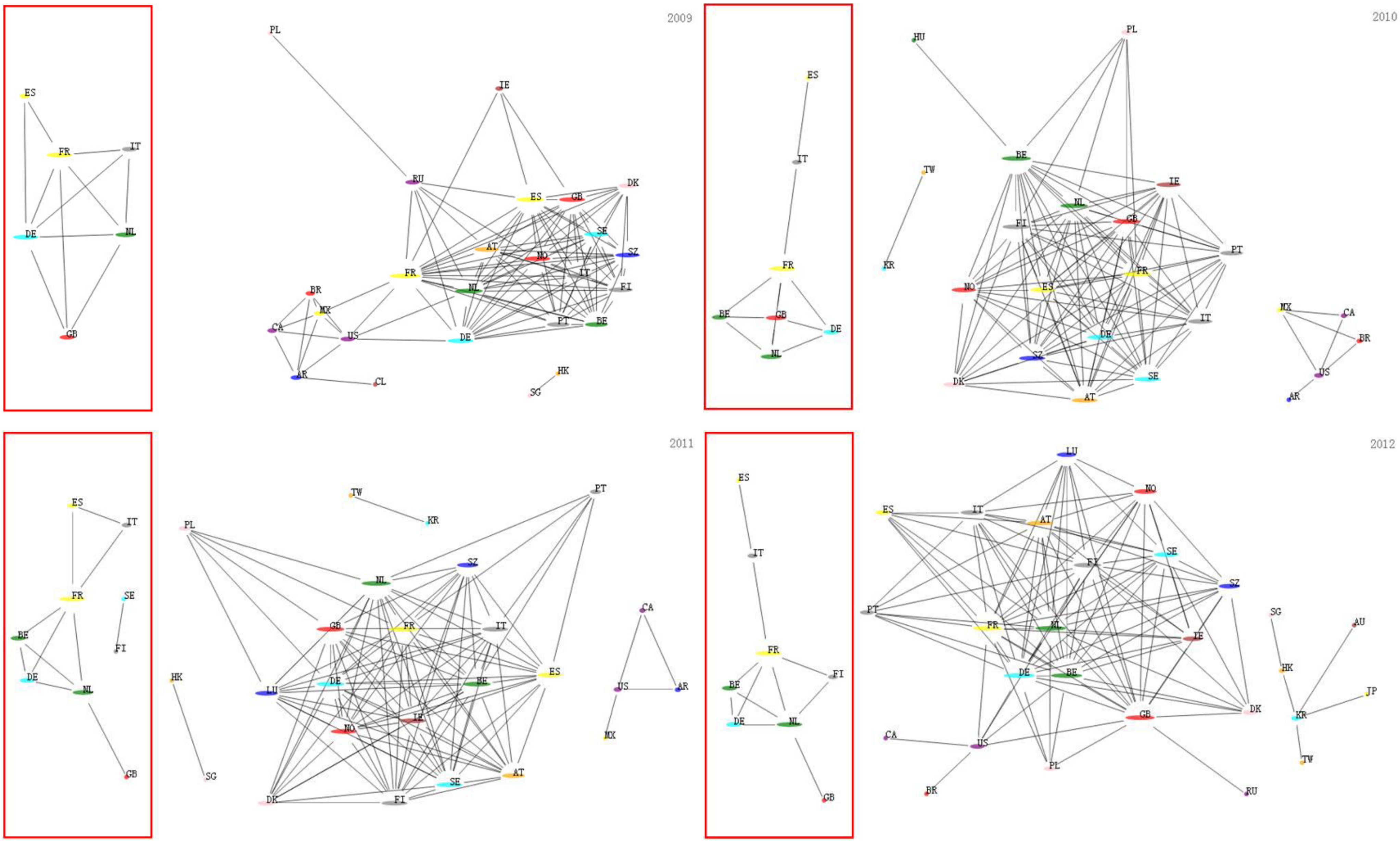
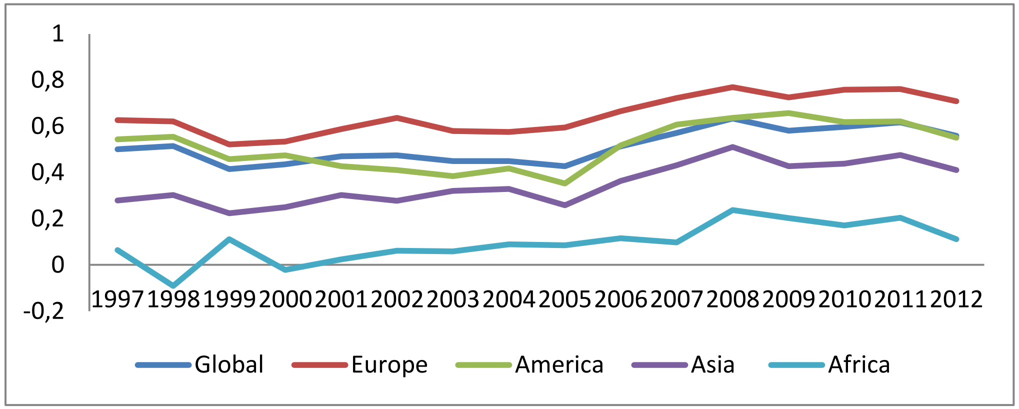


Figure 3: Threshold of MSTN



Period/Year		1997-2000				2001-2004			
		1997	1998	1999	2000	2001	2002	2003	2004
	Global	0.501	0.514	0.415	0.435	0.470	0.475	0.449	0.449
	Europe	0.627	0.621	0.522	0.534	0.588	0.636	0.580	0.576
Thresholds	America	0.544	0.555	0.458	0.474	0.427	0.411	0.385	0.417
	Asia	0.279	0.303	0.223	0.250	0.302	0.278	0.321	0.329
	Africa	0.065	-0.091	0.112	-0.021	0.024	0.061	0.059	0.089
Period/Year		2005-2008				2009-2012			
		2005	2006	2007	2008	2009	2010	2011	2012
	Global	0.427	0.513	0.572	0.633	0.581	0.597	0.617	0.559
	Europe	0.595	0.665	0.722	0.769	0.725	0.758	0.761	0.709
Thresholds	America	0.353	0.518	0.607	0.637	0.657	0.619	0.621	0.551
	Asia	0.258	0.364	0.432	0.510	0.427	0.438	0.476	0.411
	Africa	0.085	0.115	0.098	0.237	0.203	0.171	0.204	0.111